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ABSTRACT

This paper describes the effectiveness of a three-step indoor air quality (IAQ) program implemented by 156 schools in the states of Washington and Idaho during the 2000-2001 school year. An experienced IAQ/building science specialist conducted walk-through assessments at each school. These assessments documented deficiencies and served as an on-site training opportunity for the schools' facilities and administration staffs. Schools used the assessment findings, along with guidance from the specialist, to adopt indoor air quality practices and procedures from a "menu" of options. At least 22 options were selected by all schools, with most schools adopting more, up to as many as 58. The findings from the assessments and the specific options selected were compiled into a database to be used by school officials and agencies. A survey of schools confirmed the program's usefulness. (EV)

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SCHOOL INDOOR AIR QUALITY ASSESSMENT AND PROGRAM IMPLEMENTATION

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ABSTRACT

156 schools in the states of Washington and Idaho adopted individualized indoor air quality (IAQ) programs during the 2000-2001 school year. An experienced IAQ/building science specialist conducted walk-through assessments at each school. These assessments documented deficiencies and served as an on-site training opportunity for the school's facilities and administration staff. Schools used the assessment findings, along with guidance from the specialist, to adopt indoor air quality practices and procedures from a "menu" of options. At least 22 options were selected by all schools, with most schools adopting more - up to as many as 58. The findings from the assessments and the specific options selected were compiled into a database to be used by school officials and agencies. A survey of schools was conducted to evaluate the effectiveness of the program and usefulness of the specific options.

INDEX TERMS

School Indoor Air Quality, Classrooms, Portable Classrooms, Indoor Air Program, School Ventilation

INTRODUCTION

Problems associated with the indoor environmental conditions existing in US schools have been documented (Daisey and Angell, 1998) (U.S.GAO, 1995a, 1995b, and 1996). One of the goals of the United States Environmental Protection Agency (EPA) has long been the implementation of the *EPA Indoor Air Quality (IAQ) Tools for Schools (TFS) Action Kit* (U.S. EPA, 2000) in every school in the United States. Despite the excellent resource materials provided in the *TFS Action Kit*, most northwest schools have been reluctant to take meaningful action. The Washington State University Energy Program and the Northwest Air Pollution Authority collaborated to create and deliver a streamlined approach to implementing the *TFS Action Kit*, using a "3-Step IAQ Program" for schools in the states of Washington and Idaho. The "3-Step IAQ Program" was designed to be easy to understand and use, and result in schools taking 3 action steps: 1) assign responsibility for IAQ; 2) assess the IAQ in their buildings; and 3) adopt good practice IAQ policies and procedures.

Historically, the authors have found that school officials are often reluctant to allow their facilities to undergo IAQ assessment, for fear that the process or findings may create concern among staff members and/or lead to further demands on limited staff time and budgets. However, when approached with the "3-Step IAQ Program", 156 schools

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readily agreed to participate and ultimately created their own individualized IAQ Programs, while only 2 declined the opportunity. This "3-Step IAQ Program" approach may prove useful in other IAQ implementation efforts in schools around the country.

METHODOLOGY

Early in the 2000-2001 school year, the first of 156 schools to complete the "3 Step IAQ Program" were easily recruited for the program, as they had previously attended IAQ workshops conducted by the authors, or had contacted the authors for assistance on IAQ issues. The remaining schools were recruited using these first schools as references. A majority of schools in 7 counties in the northeast corner of Washington participated due largely to coordination efforts of the risk manager for Educational Service District #101.

Each school selected an IAQ Coordinator (Step 1). Generally, the facility manager accepted this role, unless another individual had a particular interest in IAQ issues. Ideally, the school IAQ walk-through assessments (Step 2) began with a brief orientation meeting with the school principal and the IAQ team. The assessment team often included the facility manager, mechanical system technician, custodial supervisor, school custodian, nurse, and others interested in gaining an understanding of IAQ fundamentals and use of IAQ monitoring equipment. Local health officials and regional EPA staff were invited to participate in the assessments and gain IAQ field experience.

Assessments generally consisted of a half-day inspection of the school, led by an experienced IAQ/building science specialist. The teachers and other school staff were notified in advance that each occupied classroom would be visited briefly by the assessment team, and were encouraged to discuss concerns or problems related to IAQ or comfort. During the walk-through virtually all occupied classrooms and offices were visited. Obvious or potential indoor air pollutants, adequacy of outside air ventilation, mechanical systems, building and finish details, and operation and maintenance procedures were noted. Outside the building, the air intakes were checked for adequate distance from sources of potential air pollutants and inspected for debris, moisture, and filtration. The exterior was also assessed for potential pollutant sources, roof and site drainage, and the location of combustion equipment flues, exhaust vents, and plumbing vent stacks. Storage areas, crawl spaces and tunnels were checked. In addition to deficiencies, the team was also careful to note and emphasize existing conditions, as well as operation and maintenance procedures that represented good practice. The team used basic measurement equipment: carbon dioxide and carbon monoxide analyzers, digital temperature and relative humidity meter; tracer smoke tubes and micro-manometers; air flow capture hood; surface and pin-type moisture meters; and a real-time particle counter. The researchers believe this equipment is adequate to identify the majority of IAQ deficiencies generally found in schools. Step 2 walk-through assessment results are presented in Table 1.

Table 1. Results of walk-through assessments in 156 schools.

Number of classrooms [1] (3,801 visited)	Parameter	Percent of classrooms [1] (3801 visited)
1,616	carbon dioxide greater than 1,000 ppm	42.5
Number of portable classrooms (180 visited)	**Parameter**	**Percent of portable classrooms (180 visited)**
119	carbon dioxide greater than 1,000 ppm	66
46	ventilation systems turned off	25.5
18	no mechanical ventilation system	10
Number of buildings [2] (156 Total)	**Parameter**	**Percent of schools (156 Total)**
57	at least one classroom with CO_2 greater than 2,000 ppm	36.5 %
10	at least one classroom with CO_2 greater than 3,000 ppm	6.4 %
4	at least one classroom with CO_2 greater than 4,000 ppm	2.5 %
19	no classrooms with CO_2 greater than 1,000 ppm	12.2 %
131	carpet in the classroom	84 %
79	carpet in the hallways	50.6 %
105	faulty exhaust fans	67.3 %
15	photocopiers vented to outdoors	9.6 %
10	laminators vented to outdoors	6.4 %
103	custodial chemical metering system	66 %
39	wood and/or metal shop	25 %
9	faulty shop exhaust	23.1%
85	water-stained ceiling tiles	54.5%
72	animals in at least one classroom	46.2%
132	schools with combustion equipment	84.6%
7	schools with carbon monoxide alarms [2]	5.3 % [3]

[1] The 118 portable classrooms are included in the 3,801 total classroom count.
[2] The 118 portables are not counted as separate buildings.
[3] Percent of schools with combustion equipment having carbon monoxide alarms

Because the walk-through served as a unique and valuable training opportunity, the team wanted to use measurement equipment that was readily available, relatively inexpensive, and would likely be used by school personnel in the future. To the extent possible, the

walk-through equipment was also made available for loan to participating school districts to check IAQ conditions and mechanical system operation after recommended changes were completed.

To accomplish Step 3, each school adopted an individualized IAQ program to address current deficiencies and to help prevent IAQ problems from occurring in the future. The authors believe that by assisting schools to adopt an IAQ program tailored to their individual needs, these custom programs will more likely be "institutionalized" by the school, and are more likely to have an enduring and positive impact on the IAQ of the school. The researchers provided each school with a detailed report of the walk-through findings and a prioritized list of suggested corrections for existing IAQ deficiencies and/or improvements to operation and maintenance practices. School personnel used the findings and recommendations to select the most appropriate options, or elements, for their school's IAQ Program.

Schools selected IAQ Program elements from a list ("menu") of suggested options or elements organized into 8 categories: policy and guidance, source controls, ventilation, operation & maintenance, classroom management, curriculum & student involvement, documentation, and communications & awareness. Each of the categories provides 8 to 10 suggested options, and 5 to 7 fill-in-the-blank spaces, to allow the schools to adopt some self-selected elements not on the list. All of the schools completed this step.

Each school's custom IAQ program was entered into a database that will provide insight into which of the program elements were most often selected, and those specific elements rarely or never selected. Upon creation and adoption of their custom IAQ Program, each school was presented with a full color certificate recognizing their participation in the program and for *"adopting best practices for improved IAQ."* Prominent display of the certificate is expected to motivate the school to maintain, expand, and refine their IAQ program over time.

RESULTS AND IMPLICATIONS

The success of the 3-Step Program is evidenced by the number of schools completing the program (all 156 schools), and by the wide range of schools participating (districts with 1 building up to large districts with 20 buildings, Mean = 5). None of the schools expressed difficulty in selecting and assigning the IAQ coordinator to complete Step 1. For the majority of schools, the coordinator was an individual, generally the facility director, lead maintenance mechanic, or the building operator (often the head custodian). A few schools used a team approach such as their safety committee as the "coordinator".

The Step 2 walk-through assessments clearly show the following:

- A significant number of schools have ventilation deficiencies and exhaust fan failures. 42% of the classrooms visited had CO_2 levels above 1,000 ppm, and 67 % of the schools had exhaust fans that were not functioning properly.

- The schools also had 180 portable classrooms, with 66% of these portable classrooms having CO_2 levels above 1,000 ppm. Ventilation systems in 46 portables were turned off, and 18 portables had no mechanical ventilation system.
- Carpets are widely used in the schools and office equipment is rarely vented to the exterior.
- Animals were present in classrooms in a majority of the schools.
- Only 4% of schools with combustion equipment had carbon monoxide (CO) alarms installed.

All of the schools completed the Program's Step 3 by selecting policies, guidance, and operation and maintenance practices from a list or "menu" of 80 options. The minimum number of options selected was 24, with most of the schools adopting up to 58 options to create their IAQ program. Some schools identified and adopted elements that were not on the list.

The authors conducted a follow-up telephone phone survey allowing the IAQ coordinators to evaluate the relative success of the 3 Step program. IAQ coordinators (representing 94 % of the schools) were successfully contacted by telephone and asked to respond to 10 questions regarding the 3 Step program with the following subjective ratings: "Don't Know"; Strongly Disagree"; "Disagree"; "Agree"; "Strongly Agree".

Responses to the 10 question survey revealed that:

- All of IAQ coordinators "agreed" or "strongly agreed" *that the 3 Step Program was useful in identifying important indoor air quality issues in their buildings; helped staff more fully understand IAQ in their buildings; and will help prevent IAQ problems from occurring in their buildings.*
- 90% of IAQ coordinators also "agreed" or "strongly agreed" *that it was useful to have an "outside expert" conduct the IAQ assessment and assist with launching their IAQ program*; and *the school district would not have completed a thorough IAQ assessment nor established an IAQ program without competent, and relatively unbiased assistance.*
- 70 % "agreed" or "strongly agreed, *that IAQ is one of the major challenges facing their school district*; and *IAQ problems are preventable with a reasonable amount of effort and financial investment.*

- 70 % of the coordinators "agreed" and " strongly agreed" *that their schools had already responded to the highest priority recommendations developed from the assessments*;

CONCLUSIONS

The findings from walk-through assessments in 156 schools indicates a significant number of schools in the northwest have inadequate ventilation, faulty mechanical equipment, and do not have carbon monoxide alarms in zones with combustion equipment. Potential asthma triggers such as animals in classrooms, un-vented equipment, and wet building materials (which can lead to mold) also exist in many of these schools.

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The successful recruitment and subsequent full participation in this program by the 156 schools was a function of the 3-Step IAQ Program design: it was perceived as easy to understand, practical and action-oriented, non-regulatory, and included a relatively unbiased and qualified expert providing on-site guidance, training, and resources.

The majority of IAQ coordinators "agreed" or " strongly agreed" that their schools had already responded to the highest priority recommendations developed from the walk-through assessments; and "strongly agreed" that they would recommend the 3 Step IAQ Program to other school districts.

All participating schools adopted a schooi-specific IAQ program by adopting at least 24 IAQ program elements. The database of walk-through assessment findings and specific IAQ program elements adopted by these northwest schools may be useful when compared to similar data collected in other regions of the U.S.

ACKNOWLEDGEMENTS

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